

WHAT IS CLAIMED IS:

1 1. A method for determining the amount of charge which
2 can still be drawn from an energy storage battery comprising:
3 measuring current values and voltage values at at least
4 two times in a voltage response of the energy storage battery to at least
5 one current pulse, with one voltage/current value pair being obtained for
6 each of the at least two times;
7 calculating a resistance difference characteristic
8 variable utilizing the measured voltage/current value pairs; and
9 determining of the amount of charge which can still be
10 drawn from the energy storage battery utilizing the resistance difference
11 characteristic variable.

1 2. The method of Claim 1 wherein at least one of the
2 times occurs in a phase whose voltage is not characterized by
3 polarization, and at least one of the times occurs in a phase whose
4 voltage is characterized by polarization.

1 3. The method of Claim 1 wherein a first time is chosen
2 before a current pulse with a front current pulse flank, and a second time
3 is chosen after the front current pulse flank of the current pulse.

1 4. The method of Claim 1 wherein the step of calculating
2 the resistance difference characteristic variable includes:
3 calculating current differences between two current
4 values and voltage differences between two voltage values for a plurality
5 of current pulses;

6 calculating a set of difference quotients, wherein each
7 difference quotient is the quotient of a voltage difference and its
8 associated current difference; and
9 calculating the resistance difference characteristic
10 variable from the set of difference quotients.

1 5. The method of Claim 4 wherein calculating the
2 resistance difference characteristic variable comprises calculating a mean
3 value of the set of difference quotients.

1 6. The method of Claim 5 wherein the mean value is
2 calculated utilizing linear averaging.

1 7. The method of Claim 5 wherein the resistance
2 difference characteristic variable is determined only from those
3 voltage/current value pairs which are measured for comparable states of
4 charge or comparable temperatures of the energy storage battery.

1 8. The method of Claim 1 further comprising determining
2 a change in capacity of the energy storage battery from at least one of
3 the resistance difference characteristic variable and a change of the
4 resistance difference characteristic variable.

1 9. The method of Claim 1 further comprising determining
2 the amount of charge which can still be drawn from the energy storage
3 battery by means of at least one of a predetermined function and a stored
4 value table for definition of the relationship between amounts of charge
5 and resistance difference characteristic variables.

1 10. The method of Claim 4 further comprising measuring
2 the temperature of the energy storage battery and determining the

3 amount of charge which can still be drawn from the energy storage
4 battery as a function of the temperature.

1 11. The method of Claim 10 further comprising
2 normalizing the difference quotients with respect to a basic temperature.

1 12. The method of Claim 1 further comprising determining
2 the present degree of discharge of the energy storage battery and
3 determining the amount of charge which can still be drawn from the
4 energy storage battery as a function of the degree of discharge.

1 13. The method of Claim 1 further comprising applying at
2 least one current pulse in one current direction to the energy storage
3 battery.

1 14. The method of Claim 1 further comprising applying a
2 sequence of current pulses to the energy storage battery, with the current
3 direction of the current pulses changing alternately.

1 15. The method of Claim 1 wherein the magnitude of the
2 current values is less than a 10-hour current of the energy storage
3 battery.

1 16. The method of Claim 15 wherein the magnitude of the
2 current values is less than a 50-hour current of the energy storage
3 battery.

1 17. The method of Claim 15 wherein the magnitude of the
2 current values is less than a 200-hour current of the energy storage
3 battery.

1 18. The method of Claim 1 wherein a current change
2 takes place between two measurements of two voltage/current value

3 pairs, with the magnitude of the current change being greater than a
4 5000-hour value of the current of the energy storage battery.

1 19. The method of Claim 18 wherein the magnitude of the
2 current change is greater than a 1000-hour value of the current of the
3 energy storage battery.

1 20. The method of Claim 18 wherein the magnitude of the
2 current change is greater than a 200-hour value of the current of the
3 energy storage battery.

1 21. The method of Claim 18 wherein the current change
2 takes place at a current rate of change whose magnitude is greater than
3 the 5000-hour current of the energy storage battery per second.

1 22. The method of Claim 19 wherein the current rate of
2 change is greater than the 1000-hour current per second.

1 23. The method of Claim 20 wherein the current rate of
2 change is greater than the 200-hour current per second.

1 24. The method of Claim 1 wherein the resistance
2 difference characteristic variable is determined only from those
3 voltage/current value pairs whose first current voltage/current value pair
4 at a first time was measured at most 10 seconds before a current change.

1 25. The method of Claim 1 wherein the resistance
2 difference characteristic variable is determined only from those
3 voltage/current value pairs whose first current voltage/current value pair
4 at a first time was measured at most 1 second before a current change.

1 26. The method of Claim 1 wherein the resistance
2 difference characteristic variable is determined only from those

3 voltage/current value pairs whose first current voltage/current value pair
4 at a first time was measured at most 0.1 second before a current change.

1 27. The method of Claim 1 wherein the resistance
2 difference characteristic variable is determined only from those
3 voltage/current value pairs whose second current voltage/current value
4 pair at a second time was measured at the earliest 0.1 second after the
5 current change.

1 28. The method of Claim 1 wherein the resistance
2 difference characteristic variable is determined only from those
3 voltage/current value pairs whose second current voltage/current value
4 pair at a second time was measured at the earliest 1 second after the
5 current change.

1 29. The method of Claim 1 wherein the resistance
2 difference characteristic variable is determined only from those
3 voltage/current value pairs whose second current voltage/current value
4 pair at a second time was measured at the earliest 10 seconds after the
5 current change.

1 30. The method of Claim 1 wherein the time intervals
2 between the at least two times is temperature-dependent, with the time
3 interval being greater for higher temperatures than for lower
4 temperatures.

1 31. The method of Claim 1 wherein the resistance
2 difference characteristic variable is determined only from voltage/current
3 value pairs which are measured at two times and for which the second
4 voltage/current value pair was measured only when the time integral of
5 the current flowing, starting from the time of a current change after the
6 measurement of the first voltage/current value pair to the second time of

7 the measurement of the second voltage/current value pair has a value of
8 at least 0.01 mAs per ampere hour of storage capacity of the energy
9 storage battery.

1 32. The method of Claim 1 wherein the resistance
2 difference characteristic variable is determined only from voltage/current
3 value pairs which are measured at two times and for which the second
4 voltage/current value pair was measured only when the time integral of
5 the current flowing, starting from the time of a current change after the
6 measurement of the first voltage/current value pair to the second time of
7 the measurement of the second voltage/current value pair has a value of
8 at least 0.1 mAs per ampere hour of storage capacity of the energy
9 storage battery.

1 33. The method of Claim 1 wherein the resistance
2 difference characteristic variable is determined only from voltage/current
3 value pairs which are measured at two times and for which the second
4 voltage/current value pair was measured only when the time integral of
5 the current flowing, starting from the time of a current change after the
6 measurement of the first voltage/current value pair to the second time of
7 the measurement of the second voltage/current value pair has a value of
8 at least 1 mAs per ampere hour of storage capacity of the energy storage
9 battery.

1 34. The method of Claim 18 further comprising utilizing an
2 approximately standard current profile of the current pulses, with the
3 current profile being determined from current rates of change of the
4 current change between the voltage/current value pairs, the time period
5 between a first voltage/current value pair and the current change, and the
6 time period between the current change and the second voltage/current
7 value pair.

1 35. The method of Claim 1 wherein the current pulses are
2 applied to the energy storage battery by means of an electrical switching
3 unit.

1 36. The method of Claim 1 further comprising comparing
2 at least one of the resistance difference characteristic variable and the
3 amount of charge which can be drawn with a threshold value.

1 37. The method of Claim 36 further comprising outputting
2 at least one of the overshooting of the threshold value, the ratio of the
3 resistance difference characteristic variable or the amount of change
4 which can be drawn from the storage battery to the threshold value, and
5 the discrepancy between the resistance difference characteristic variable
6 or the amount of charge which can be drawn from the storage battery
7 and the threshold value.

1 38. The method of Claim 36 wherein the threshold value is
2 defined as a function of temperature of the energy storage battery.

1 39. The method of Claim 1 further comprising determining
2 at least one of the total present storage capacity of the energy storage
3 battery and the amount of charge with which the energy storage battery
4 can be charged by correlating the calculated amount of charge which can
5 be drawn from the storage battery with at least one of a present degree
6 of discharge and a present state of charge.

1 40. The method of Claim 1 further comprising determining
2 a wear characteristic variable in order to describe reduction in storage
3 capacity of the energy storage battery by correlating the determined total
4 present storage capacity of the energy storage battery with the storage

5 capacity of the energy storage battery when new, or with the nominal
6 value of the storage capacity of the energy storage battery when new.

1 41. The method of Claim 40 further comprising comparing
2 the wear characteristic variable with a threshold value and outputting a
3 servicing message as a function of the comparison.

1 42. The method of Claim 1 wherein the energy storage
2 battery is a lead-acid rechargeable battery.

1 43. The method of Claim 1 further comprising linking the
2 resistance difference characteristic variable to a state variable for the
3 energy storage battery.

1 44. The method of Claim 43 wherein the state variable is
2 selected from state of charge, power capability of the energy storage
3 battery, and characteristic variables for effects which contribute to wear
4 in an energy storage battery.

1 45. The method of Claim 1 further comprising predicting
2 the behavior of the energy storage battery in an operating state other than
3 a present operating state.

1 46. An energy storage battery having measurement means
2 and processor-controlled evaluation means configured to carry out a
3 method comprising the steps of:

4 measuring current values and voltage values at at least
5 two times in a voltage response of the energy storage battery to at least
6 one current pulse, with one voltage/current value pair being obtained for
7 each of the at least two times;

8 calculating a resistance difference characteristic
9 variable utilizing the measured voltage/current value pairs; and

10 determining of the amount of charge which can still be
11 drawn from the energy storage battery utilizing the resistance difference
12 characteristic variable.